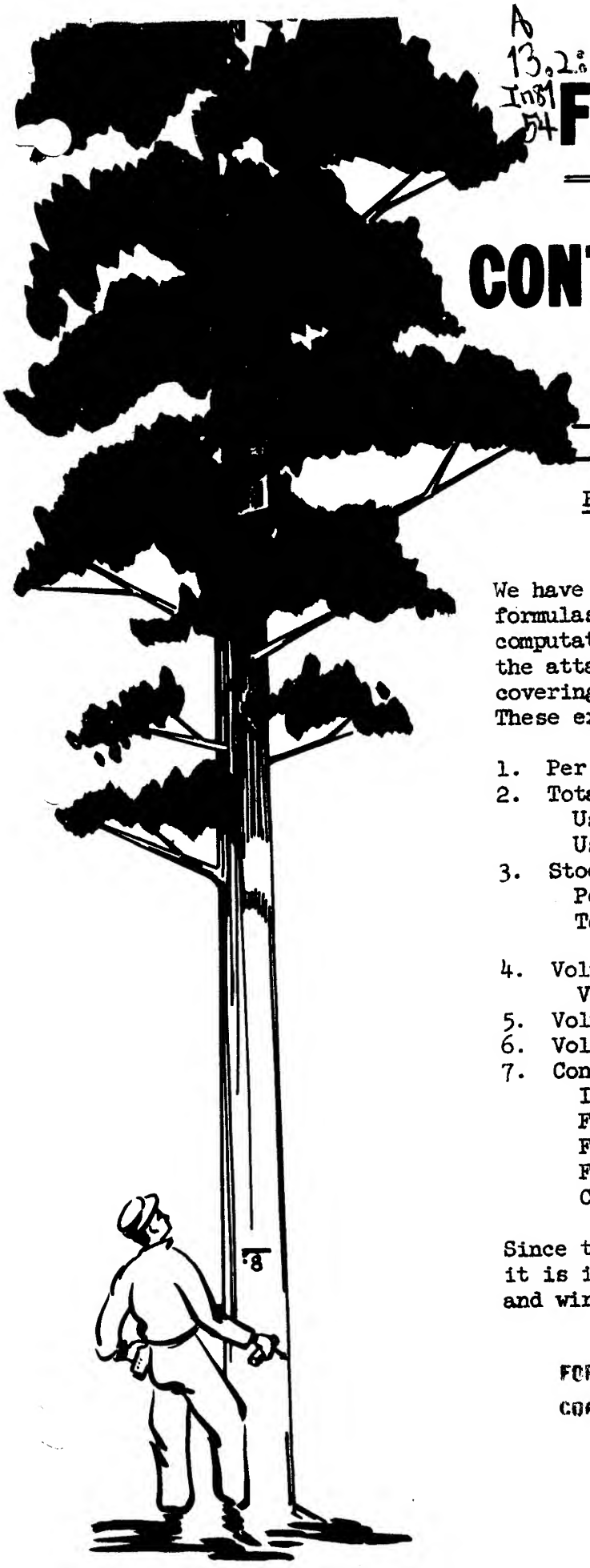

FOREST CONTROL by CONTINUOUS INVENTORY

"Today I have grown taller from walking with the trees."
...Karle Wilson

Milwaukee, Wis. Sept. 1958 No. 54

FORMULAS AND CONVERTORS FOR PUNCH CARD COMPUTING INDUSTRIAL C.F.I. CASES

We have at last brought together all of the common formulas and converting factors used in the machine computation of industrial C.F.I. cases. Each of the attached sheets gives a completed example covering each of the formulas and convertors. These examples include:

1. Per acre reductions
2. Total expansions
   - Using per acre value times expanded area
   - Using expansion factor times volume in sample
3. Stock and stand tables
   - Per acre values by the reciprocal method
   - Total forest values by the expansion factor method
4. Volume per tree with the Residual Cubic Foot Volume formula
5. Volume per tree with the cord C.F.I. formula
6. Volume per tree of body wood in cubic feet
7. Converting factors:
   - International to Scribner
   - For limbwood in cubic feet
   - For top and body wood combined in cubic feet
   - For top wood in cubic feet
   - Cubic feet to cords

Since these formulas are standard for C.F.I. cases it is important to save the machine specifications and wiring diagrams for repeated use.

CAL STOTT,
Region 9

The Forester

STANDARD SYMBOLS FOR MACHINE CALCULATIONS WITH PUNCH CARD ACCOUNTING
INDUSTRIAL C.F.I. CASES

	Maximum Decimals	
r	———	Reciprocal
Pa	———	Per acre values
Sp	x.xx	Species correction factor
So	x.xx	Soundness correction factor
L	xx.	Usable length of each tree
5	x.	Per acre factor for fifth acre plots
7	x.	Per acre factor for seventh acre plots
Ea	——— .xxxx	Expanded area or (Ae x N)
X	———	Expanded volume, tree count or basal area
V	———	Volume
Vi	xxxx.x	Volume per tree, International, Board Feet
Vs	xxxx.x	Volume per tree, Scribner, Board Feet
Vpcu	xxx.xx	Volume per tree, pulpwood, cubic feet
Vpcd	x.xxx	Volume per tree, pulpwood, cords
Vlcu	xx.xx	Volume per tree, limbwood, cubic feet
Vtcu	xx.xx	Volume per tree, topwood, cubic feet
Vbcu	xxx.xx	Volume per tree, bodywood, cubic feet
Vlcd	.xxx	Volume per tree, limbwood, cords
Vtcd	.xxx	Volume per tree, topwood, cords
Vbcd	x.xxx	Volume per tree, bodywood, cords
Na	———	Number of sample plots measured in each area breakdown
N	———	Number of sample plots measured on total forest
T	———	Volume, tree count or basal area in sample
Cs	.xxx	Converting factor; International to Scribner log scale
Ct	.xxxx	Converting factor; top wood above sawlog length
Cl	.xxxx	Converting factor; limb wood above top wood
Cb	.xxxxx	Converting factor; sawlogs 8" top, to cu. ft. 4" top
A	———.xxxx	Area, total forest
Ae	xxx.xxxx	Area expander; area of forest represented by each plot or $\frac{(A + N)}{}$
Af	xxxx.xxxx	Area expansion factor for volume, basal area or tree count
As	———	Area of measured sample or plot acres (N + 5) or (N + 7)
a	———	Individual tree residual volume factor
b	———	Individual tree length multiplying factor
$\frac{1}{79}$	.xxxxx	Converting factor; cubic feet to cords. The reciprocal is .01266

Definitions:

Limb wood - Pieces over 4' long with a minimum 4" top d.i.b. above the top wood.
Top wood - 100 inch pulp sticks to a minimum 4" D.I.B. above the bodywood
Body wood - The sawlog portion of the tree

April, 1958

MACHINE CALCULATING THE REDUCTION TO PER ACRE VALUES
INDUSTRIAL C.F.I. CASES

THE FORMULA

$$Pa = T\left(\frac{5}{Na}\right)$$

IN WHICH

	DECIMALS
Pa = Per acre value	xx . xxxx
5 = Per acre factor for fifth acre plots	x .
T = Number of cords* in the sample	xxx . xxx
Na = Number of sample plots measured	xx .

THE EXAMPLE

5 = Per acre factor for fifth acre plots
T = 175.566 cords
Na = 25. plots

THE SOLUTION

$$Pa = 175.566\left(\frac{5}{25}\right)$$

$$Pa = 35.1132 \text{ cords}$$

The average Industrial C.F.I. case uses this formula on at least 500 separate calculations

W. W. BARTON Region 7
GEORGE SEMMENS Region 9
CAL STOTT Region 9

April, 1958

* Cubic feet and board feet can also be computed

MACHINE CALCULATING THE TOTAL EXPANSION USING PER ACRE VALUES
INDUSTRIAL C.F.I. CASES

THE FORMULA

$$X = (Pa)(Ea)$$

IN WHICH		DECIMALS
X	= Expanded volume	xxxxx .
Pa	= Per acre value in cords*	xx . xxxx
Ea	= Expanded area	xxxx . xxxx

THE EXAMPLE

Pa = 35.1132 cords per acre
Ea = 1000.1241 acres

THE SOLUTION

$$X = (35.1132)(1000.1241)$$

X = 35,118. cords

The average Industrial C.F.I. case uses this formula, or the one on Page 4, on two to three hundred volume expansions

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CAL STOTT Region 9

April, 1958

* Cubic feet and board feet can also be computed

MACHINE CALCULATING THE TOTAL EXPANSION USING THE EXPANSION FACTOR
INDUSTRIAL C.F.I. CASES

THE FORMULA

$$X = (T)\ (Af)$$

IN WHICH		DECIMALS
X	= Expanded volume	xxxxx .
Af	= Area expansion factor	xxx . xxxx
T	= Number of cords* in the sample	xxx . xxx
Ea	= Expanded area, 1000.1241 acres	xxxx . xxxx
As	= Plot acres or area of sample $\frac{25}{5}$	x . x

THE EXAMPLE

Af = Ea divided by As or 1000.1241 + 5 = 200.0248
T = 175.566 cords

THE SOLUTION

$$X = (175.566)\ (200.0248)$$

$$X = 35{,}118.\ \text{cords}$$

The average Industrial C.F.I. case uses this formula, or the one on Page 3, on two to three hundred volume expansions

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April, 1958

* Cubic feet and board feet can also be computed

MACHINE CALCULATING THE REDUCTION TO PER ACRE AND THE TOTAL EXPANSION IN STOCK AND STAND TABLES

INDUSTRIAL C.F.I. CASES

THE FORMULA

$$Pa = (T)\ (r)$$

$$X = (T)\ (Af)$$

IN WHICH

		DECIMALS
Pa	= Per acre value	xx . xxxx
X	= Expanded volume	xxxxx .
T	= Number of cords* in the sample	xxx . xxx
Af	= Area expansion factor for cords	xxx . xxxx
r	= Reciprocal of acres in sample	. xxxx

THE EXAMPLE

T = 175.566 cords
Af = 200.0248 factor
r = .2000 reciprocal

THE SOLUTION

Pa = (175.566) (.2000)
Pa = 35.1132 cords

X = (175.566) (200.0248)
X = 35,118. cords

Industrial C.F.I. cases prepare 10 to 50 stock and stand tables in 2" DBH classes for about 12 species. This requires 6,000 to 30,000 separate per-acre calculations using this formula. The answers are given in cords, board feet, tree count and basal area. There are an additional 2,000 to 10,000 separate calculations for the total expansion of board foot and cord volumes.

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CAL STOTT Region 9

April, 1958

* Cubic feet and board feet can also be computed

MACHINE CALCULATING THE PULPWOOD VOLUME OF INDIVIDUAL TREES IN CUBIC FEET AND CORDS

THE RESIDUAL VOLUME FORMULA IN CUBIC FEET AND CORDS

$$Vp = \left[a + (b \times L)\right] (Sp)\ (So)\ (r)$$

IN WHICH		DECIMALS
Vp	= Pulpwood volume per tree, net	
Vpcu	= Pulp volume per tree in cubic feet, net	xx . xx
Vpcd	= Pulp volume per tree in cords, net	. xxx
a	= Residual volume factor	xx . xxx
b	= Length multiplying factor	x . xxxxx
L	= Usable length of each tree	xx .
Sp	= Species correction factor	x . xx
So	= Soundness correction factor	x . xx
r	= Cubic foot to cord converting reciprocal for $\frac{1}{79}$	. xxxxx

THE EXAMPLE FOR A RED OAK TREE

a = .699 factor
b = .18927 factor
Sp = 1.00 factor
So = 0.86 factor
r = .01266 reciprocal

DBH = 8.0 inches
L = 32. feet

THE SOLUTION

$$Vp = \left[.699 + (.18927 \times 32)\right] (1.00)\ (0.86)\ (.01266)$$

Vpcu = 6.76 cubic feet gross
Vpcu = 5.81 cubic feet net
Vpcd = .074 cords net

The average Industrial C.F.I. case uses this formula on 2,000 to 10,000 pulpwood trees

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Note: Tables of Residual Volume factors to be published soon in newsletter

MACHINE CALCULATING THE BOARD FOOT VOLUME OF INDIVIDUAL TREES
INTERNATIONAL AND SCRIBNER LOG SCALE
INDUSTRIAL C.F.I. CASES

THE C.F.I. FORMULA IN BOARD FEET

$$Vs = \left[a + (b \times L)\right] (Sp)\ (So)\ (Cs)$$

IN WHICH	DECIMALS
Vi = Volume per tree in board feet International *	xxx . x
Vs = Volume per tree in board feet Scribner *	xxx . x
a = Volume factor	xx . xx
b = Length multiplying factor	x . xx
L = Usable length of each tree	xx .
Sp = Species correction factor	x . xx
So = Soundness correction factor	x . xx
Cs = International to Scribner converting factor	. xxx

THE EXAMPLE FOR A RED OAK TREE

a = 28.16 factor
b = 6.55 factor
} See Newsletter No. 6, 9/1954

Sp = 1.04 factor
So = 0.97 factor
Cs = .894 factor

DBH = 18.0 inches
L = 32. feet

THE SOLUTION

THE SOLUTION

$$Vs = \left[28.16 + (6.55 \times 32)\right] (1.04)\ (0.97)\ (.894)$$

Vi = 247.3 board feet gross International
Vi = 239.9 board feet net International
Vs = 214.5 board feet net Scribner

The average Industrial C.F.I. case uses this formula on 2,000 to 10,000 sawlog trees.

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April, 1958

* Cubic feet and cords can also be computed

Note: Tables of converting factor to be published in future newsletters

MACHINE CALCULATING THE CUBIC FOOT VOLUME OF THE SAWLOG SECTIONS OF TREES (BODYWOOD)

INDUSTRIAL C.F.I. CASES

THE FORMULA FOR BODYWOOD

$$Vbcu = \left[a + (b \times L) \right] (Sp) (So)$$

IN WHICH		DECIMALS
Vbcu	= Bodywood volume per tree in cubic feet	xx . xx
a	= Residual volume factor **	xx . xxx
b	= Length multiplying factor **	x . xxx
L	= Usable length of each tree, sawlogs (bodywood)	xx .
Sp	= Species correction factor	x . xx
So	= Soundness correction factor	x . xx

THE EXAMPLE FOR A RED OAK TREE

a = 11.600 factor
b = 1.333 factor
Sp = 1.04 factor
So = 0.93 factor

DBH = 22.0 inches
L = 30. feet

THE SOLUTION

$$Vbcu = \left[11.600 + (1.333 \times 30) \right] (1.04) (0.93)$$

Vbcu = 53.65 cu. ft. (gross)
Vbcu = 49.89 cu. ft. (net)

The average Industrial C.F.I. case might use this formula on 5,000 to 10,000 trees.

GEORGE SEMMENS Region 9
CAL STOTT Region 9

April, 1958

** From Lake States Forest Experiment Station, University Farm, St. Paul, Minnesota, Technical Note 382

NOTE: Tables of residual volume, length multiplying and converting factors to be published in future newsletters.

MACHINE CALCULATING THE LIMB WOOD VOLUME OF INDIVIDUAL TREES IN CUBIC FEET AND CORDS

INDUSTRIAL C.F.I. CASES

THE FORMULA FOR LIMB WOOD

$$Vl = (Vi)\ (Sp)\ (Cl)\ (r)$$

IN WHICH

		DECIMALS
Vl = Limb wood volume per tree in cubic feet or cords	cu. ft.	xx . xx
	cords	. xxx
Vi = Volume per tree in board feet, International, gross		xxx . x
Cl = Converting factor, limb wood above top wood		. xxxx
Sp = Species correction factor		x . xx
r = Cubic foot to cord converting reciprocal for $\frac{1}{79}$		. xxxxx

THE EXAMPLE FOR AN ELM TREE

Vi	= 104.8	board feet
Sp	= 1.05	factor
Cl	= .0425	factor
r	= .01266	reciprocal
DBH	= 14.0	inches
L..	= 24.	feet (sawlogs)

THE SOLUTION

Vl = (104.8) (1.05) (.0425) (.01266)
Vlcu = 4.68 cubic feet (net)
Vlcd = .059 cords (net)

The average Industrial C.F.I. case might use this formula on 5,000 to 10,000 sawtimber trees. Individual tree values are not reliable but totals for groups of trees give a roughly reliable answer on the cubic feet of wood available in limbs. Converting factors are based on usable length classes in two-foot intervals as limb wood volume is not appreciably affected by tree diameter.

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April, 1958

NOTE: Tables of converting factors to be published in future newsletters.

MACHINE CALCULATING THE TOP AND BODY WOOD OF SAWLOG TREES IN CUBIC FEET USING CONVERTERS FROM GROSS INTERNATIONAL BOARD FOOT VOLUME

INDUSTRIAL C.F.I. CASES

THE FORMULA FOR TOP AND BODY WOOD

Vpcu = (Vi) (Sp) (Cb) (So)

IN WHICH		DECIMALS
Vpcu	= Pulp volume per tree in cu. ft., net	xx . xx
Vi	= Volume per tree in board feet, International, gross	xxx . x
Sp	= Species correction factor	x . xx
Cb	= Bd. ft. to Cu. ft. converter	. xxxxx
So	= Soundness correction factor	x . xx

THE EXAMPLE FOR A RED OAK TREE

Vi = 343.0 board feet
Sp = 1.04 factor
Cb = .15025 factor
So = 0.93 factor

DBH = 22.0 inches
L.. = 30. feet (sawlogs)

THE SOLUTION

Vpcu = (343.0) (1.04) (.15025) (0.93)
Vpcu = 53.59 gross cu. ft.
Vpcu = 49.84 net cu. ft.

The average Industrial case might use this formula on 5,000 to 10,000 trees.

GEORGE SEMMENS Region 9
CAL STOTT Region 9

April, 1958

NOTE: Tables of converting factors to be published in future newsletters.

MACHINE CALCULATING THE TOP WOOD OF INDIVIDUAL SAWLOG TREES IN CUBIC FEET AND CORDS

INDUSTRIAL C.F.I. CASES

THE FORMULA FOR TOP WOOD

$$Vt = (Vi)\ (Sp)\ (Ct)\ (r)$$

IN WHICH

		DECIMALS
Vt	= Top wood volume per tree, net	x . xx
Vtcu	= Top wood volume per tree in cubic feet, net	x . xx
Vtcd	= Top wood volume per tree in cords, net	. xxx
Vi	= Volume per tree in board feet, International, gross	xxx . x
Ct	= Converting factor - top wood above sawlog length	. xxxx
Sp	= Species correction factor	x . xx
r	= Cubic foot to cord converting reciprocal for $\frac{1}{79}$	. xxxxx

THE EXAMPLE FOR A RED OAK TREE

Vi	= 237.8	board feet
Sp	= 1.05	factor
Ct	= .0245	factor
r	= .01266	reciprocal
DBH	= 18.0	inches
L	= 32.	feet (sawlogs)

THE SOLUTION

$$Vt = (237.8)\ (1.05)\ (.0245)\ (.01266)$$

Vtcu = 6.12 cubic feet (net)
Vtcd = .077 cords (net)

The average Industrial C.F.I. case might use this formula on 5,000 to 10,000 trees. Values on individual trees are not reliable but totals for groups of trees give reliable answers. Converting factors are based on usable length classes in two-foot intervals as top wood volume is not appreciably affected by tree diameter.

GEORGE SEMMENS Region 9
CAL STOTT Region 9

April, 1958

NOTE: Tables of converting factors to be published in future newsletters.